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An Analysis on the Railway-Based Intermodal Freight Transport in Japan Regarding The Effect of Disasters

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Abstract

This paper first summarizes the damages and recoveries of transport caused by the devastating earthquake occurred in Japan in March 2011. Responses of freight railway, such as transporting immediately-needed supplies and fuel, are reviewed. The role of intermodal freight transport in supplying fuel to disaster areas is especially stressed. The necessity and importance of intermodal freight transport in the disaster recovery is discussed. Intermodal freight transport contributes to social and economic benefits by enhancing flexibility and redundancy of freight transport, as well as sustaining the vital freight flow in the disasters.

Keywords: logistics; natural disaster; railway freight; intermodal transport; relief supply

1. Introduction

The huge earthquake and the following tsunami that struck Japan on March 11, 2011 left a serious devastation and tremendous damages to Tohoku district, the northeastern region of the country. The disaster caused the massive loss of transport infrastructure such as railway tracks, seaports and airport runways, resulted in the temporary regionwide service suspension of freight as well as passenger transport. At the same time, the transport system faced a challenge to meet the soaring demand for supplying food,

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living necessities and fuel to support the evacuees in Tohoku as well as residents in the temporarily supply-scarce Tokyo region. The importance of sustaining logistics system was recognized.

Japan is vulnerable to natural disasters such as earthquakes and tropical cyclones, and transport systems repeatedly experienced severe damages and recoveries. At the same time, they played important roles in transporting relief supplies to the disaster areas. Several case studies regarding logistics system after the disaster are already provided as described later. However, most of them focus on truck and trailer transport, leaving roles of railway transport in the disaster recovery less discussed.

This paper first summarizes the damages and recoveries of different transport infrastructures caused by the devastating earthquake. Damage severity and recovery processes are compared among different transport modes. Afterwards, reviewing the role of freight railway transport played in transporting relief supplies to the disaster area, the necessity and importance of intermodal freight transport in the disaster recovery is discussed. Intermodal freight transport contributes to social and economic benefits by enhancing flexibility and redundancy of freight transport, as well as sustaining the vital freight flow in the disasters.

2. Earthquake damages to the transport infrastructure

The Tohoku Earthquake is a large-scale compound disaster which is composed of earthquake, tsunami, power outages and nuclear hazards. Homes and buildings were collapsed in 48 cities and were submerged in the tsunami waves in 62 cities. As many as 28 thousand people lost their lives or are still missing, and the number of evacuees counted up to 470 thousand.

The center of devastation located in three prefectures, namely Iwate, Miyagi and Fukushima, where some 230 thousand collapsed buildings and 400 thousand evacuees were reported. The need of supplying daily necessities and fuel for transport and heating to the large number of evacuees and refugees are radically emerged.

Earthquake damages and recovery status of the four major transport infrastructures, namely railway, expressway, airport and seaport, are summarized as shown in Fig. 1. As many as 4,400 damages are reported among 2,900km-long railway trackages throughout Tohoku region (Ministry of Land, Infrastructure, Transport and Tourism, 2011a; 2011b). Especially, as long as 325 kilometers of trackages along the Pacific coast suffered serious tsunami damages such as track and station washouts. These lines resumed operation by the end of April at the latest, except for a portion of the heavily tsunami-damaged lines and those near Fukushima I nuclear power plant. The major corridor between Tokyo and Sendai recovered from damages and restarted services on April 17th.

Railway freight service suspended operation due to the above mentioned regionwide trackage damages. Freight railway stations also suffered serious damages including building collapses and liquefactions, and tsunami washed away rolling stocks including a freight train running in Fukushima prefecture. The direct freight service between Tokyo and Sendai had been suspended until April 17th (Japan Freight Railway, 2011).

The Tohoku Shinkansen high-speed railway tracks also suffered as many as 1,200 damages. The service between Fukushima and Morioka had been suspended until April 29th (East Japan Railway Company, 2011).

As long as 870 kilometers of expressways are damaged in the earthquake. Damages include collapsed roadways, cracks and cave-ins. Recovery was relatively swift: 93% of damaged expressways had been repaired within two weeks from the devastation (Ministry of Land, Infrastructure, Transport and Tourism, 2011c).

All major seaports along the Pacific coast also suffered severe damages from the earthquake itself and also from strong tsunami waves, and at least one week was necessary for some ports to reopen tentatively,

with restrictions in the number, size and cargo tonnage of ships. Alternative ferry services began operation in the end of March, and roll-on roll-off ship services also resumed in early April (Ministry of Land, Infrastructure, Transport and Tourism, 2011a).

Sendai Airport, situated near the Pacific coast, was directly hit by the tsunami, resulting in the commercial service closure for one month. Ibaraki Airport also suffered some structural damages to the terminal buildings. Yamagata and Fukushima Airports, nearest to the devastated area, functioned as alternatives to the damaged airports. They provided 24-hour services until mid-April (Ministry of Land, Infrastructure, Transport and Tourism, 2011a).

In general, relatively prompt recovery and service resumption are achieved compared to the past major earthquakes that hit the country. However, for the case of Tokyo-Sendai corridor, freight railway required more than one month to restart operation, which is longer than expressways and seaports.

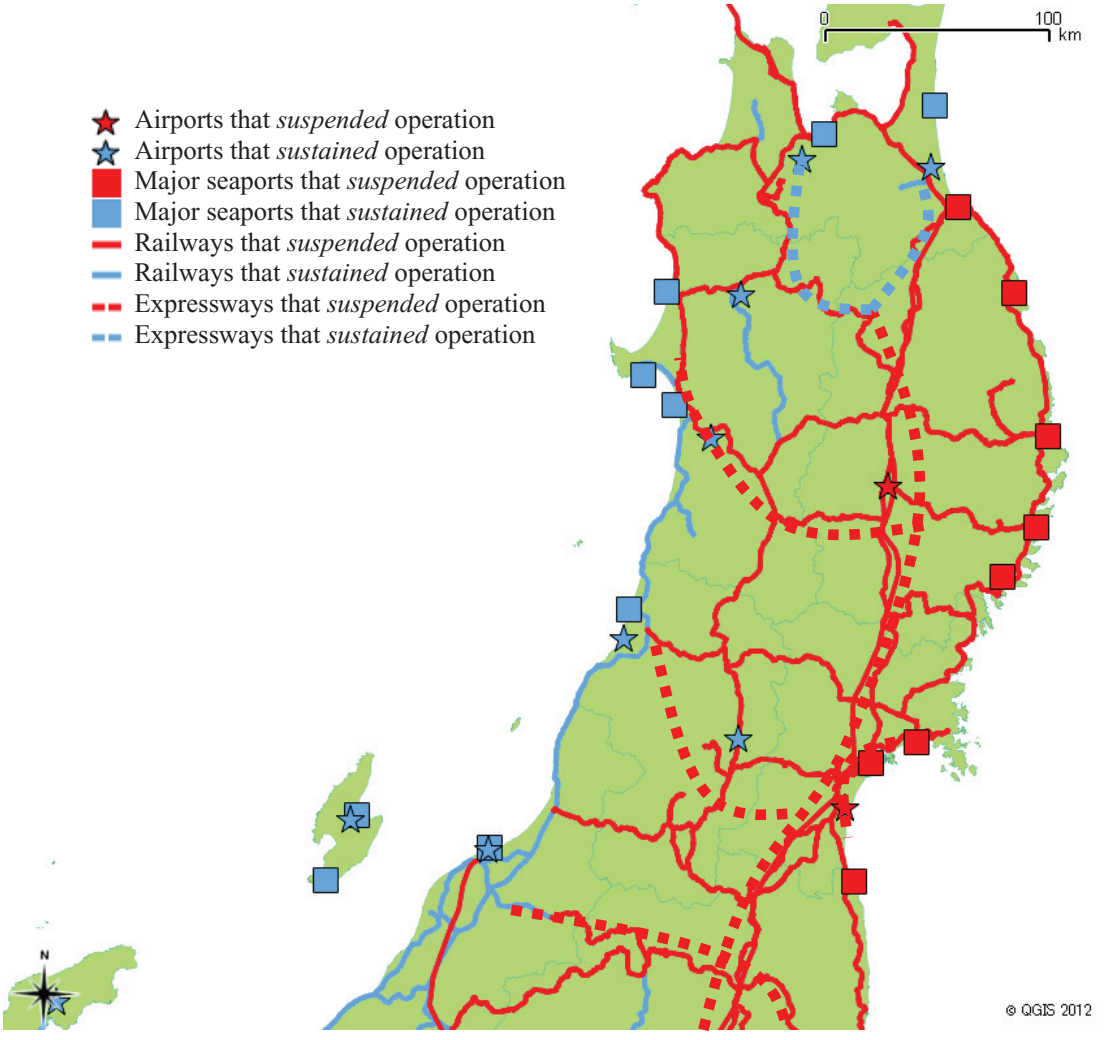

Fig. 1. Transport service status after the earthquake

3. Problems regarding logistics after disasters

Natural disasters may cause serious influences on nationwide or even worldwide logistics system. Not only the structural damages to the infrastructure itself, but earthquake also halts production facility operations, breaks supply chains, resulting in the retard of supplying manufactured goods around the world. On the other hand, rapidly increasing demands of the relief supplies need transport system to provide sufficient transport services to the devastated area.

Several researches discuss past case studies to disclose problems concerning logistics after the large scale natural disasters. The Great Hanshin Earthquake in 1995 caused serious loss of logistics services within the devastated areas, including service suspension of railways, collapsed expressways and serious traffic congestion on other roadways, which resulted in the serious shortage of relief supplies in Kobe area (Nakashita et al., 1996). The number of evacuees counted as large as 310 thousand, and the lack of supply itself was a major problem. Insufficient and unstable means of transporting relief supplies, lack of information, and mismatch of supplies and refugee needs were also blamed. It was private cars, not trucks or railways, that largely contributed.

The Niigata Chuetsu Earthquake in 2004 also damaged expressways and the Shinkansen high-speed railway tracks. However, learned from the Great Hanshin Earthquake, transport infrastructure was reinforced in advance and suffered less damage. The focus of the problem had been shifted from the lack of supplies itself to the management of storing and distributing supplies to the shelters. The importance of the disaster logistics management plan is proposed (Tamura et al., 2006).

Additionally, increase in logistics costs and worsened labor environment of truck drivers due to the wide damage to the roads are also pointed out (Takahashi et al., 2004).

The weaknesses of efficient truck-dependent logistics system after earthquakes are thus found in the past. On the other hand, advantages and issues of freight railway transport after disasters have been seldom discussed. It is important to summarize and discuss the role of freight railway transport after disasters by reviewing how freight railway transport reacted to the devastating situation.

4. Role of freight railway in the disaster recovery

One of the featured tasks that freight railway took was to transport fuel to Tohoku region. As a background, Fig. 2 indicates the amount of petroleum sales in Tohoku region (Petroleum Association of Japan, 2011). Approximately 46,000 kiloliters of petroleum was sold per day in FY2010. Also, as shown in Fig. 3, the majority of petroleum was consumed in the transport and residential sectors (Agency for Natural Resources and Energy, 2011). Note that Fig. 3 does not include fuel for power generation, and transport only includes private cars.

The Sendai Oil Refinery, the only refinery located in the Tohoku region owned by Nippon Oil with the capacity of 23,100 kiloliters per day, was heavily damaged by the earthquake and ceased operation, leaving Tohoku region unsupplied with fuel. On the other hand, more fuel was immediately needed for transport conveying relief supplies and other daily necessities. Moreover, the cold and snowy weather condition demanded more fuel for heating. However, fuel cannot be forwarded from other regions to Tohoku region since transport infrastructures in disaster area were widely destroyed.

The high-capacity freight railway promptly responded to this situation (Japan Freight Railway, 2011). One week after the earthquake, a daily fuel train running on the alternative route along the Japan Sea coast began operation between Kanagawa, where another large oil refinery locates, and Morioka, a city in the northern part of disaster area. Fig. 4 outlines the alternative routes of fuel trains. A train had a capacity of up to 800 kiloliters of gasoline and kerosene. Two weeks after the quake, another daily fuel train began using another detour route to Koriyama, a city in the southern part of disaster area. This train carried up to

1,200 kiloliters of fuel. Two daily trains made the capacity of transporting 2,000 kiloliters of fuel per day, which is almost as much as the amount of fuel transported by railway from Sendai refinery before the quake, or 10% of all fuel forwarded from around the country. These trains continued operation until April 17th, the day the direct corridor between Tokyo and Sendai restored operation.

From Morioka and Koriyama stations, lorries effectively relayed the fuel transport to the widely scattered homes, shelters and local gas stations. As much as 57,000 kiloliters of fuel, equivalent to 2,850 lorries, were transported by the effective connection between temporarily designated combination of fuel trains and lorries.

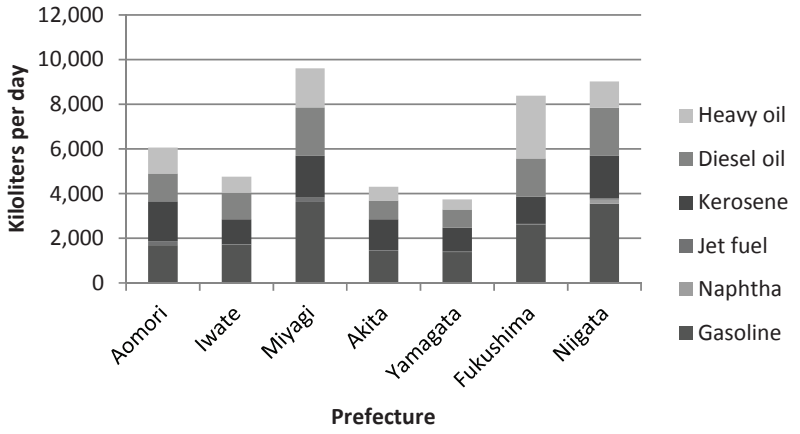

Fig. 2. Petroleum sales in Tohoku region (FY2010)

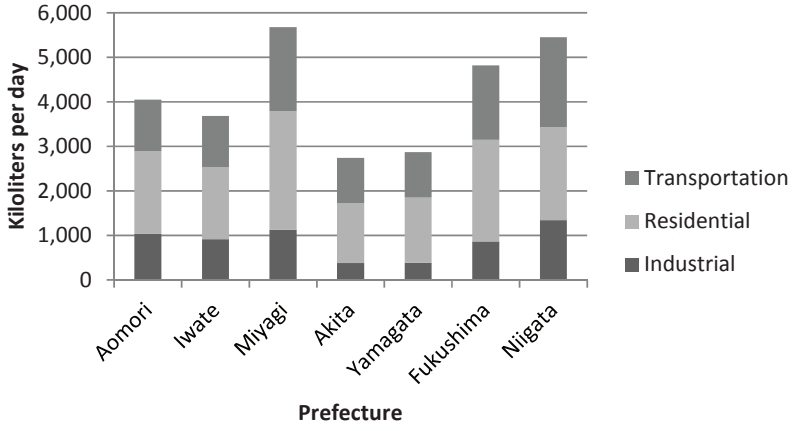

Fig. 3. Petroleum consumption in Tohoku region (FY2009)

Trucks, ships and ferries also played important roles in providing alternative freight services. Fig. 5 shows the outline of alternative freight services as of April 18th. Railway service between Tokyo and Sendai was restored on the day before; therefore railway freight could approach to Sendai directly. However, railway services in the northern or eastern part of Tohoku region remained suspended. Therefore, railway freight to and from these areas are alternatively transported with trucks, based at Morioka, Sendai and Tsuchiura. Freight to and from Hokkaido were also alternatively transported with

ferries and ships, or detoured along the west coast of Tohoku, since majority of them had to pass through devastated areas.

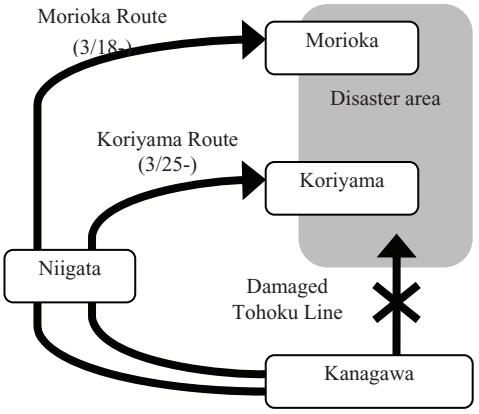

Fig. 4. Alternative routes of fuel trains

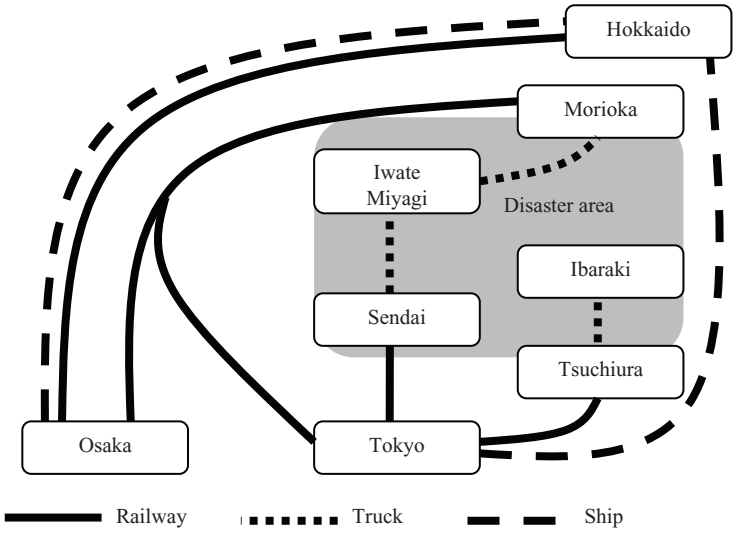

Fig. 5. Collaborative freight transport in Tohoku region after earthquake

5. Importance of intermodal freight transport

Intermodal freight transport is a notion that effectively connects multiple transport modes to enhance their advantages, as summarized in Table 1. This table also incorporates their weaknesses. As recovery proceeds, available transport modes at a time at a location changes momentarily. In such situation, efficient collaboration of different transport mode is necessary to securely accomplish transporting commodities, supplies and fuel. In particular, making use of the capacity of railway and marine transport, accuracy of railway, and flexibility of truck altogether may realize efficient intermodal freight transport.

Collaboration and cooperation among different transport modes and businesses are necessary to

achieve the intermodal freight transport. Understanding and cooperation of passenger railway companies, which own railway infrastructures, is vital. For example, in Tohoku Earthquake's case, alternative routes for fuel trains shown in Fig. 5 were not originally utilized for fuel trains. Without sincere cooperation of East Japan Railway Company, it was not able to serve alternative fuel trains within one to two weeks after the disaster. Swift forwarding of necessary rolling stocks and lorries also contributed to the intermodal fuel transport.

Another contributing factor is that Nippon Oil already utilized freight railway services before the earthquake, accounting for approximately half of all fuel transported by railway in Japan. The understanding, experience and reliance of consignors are also important.

Although it requires further infrastructure development including construction of intermodal terminals and station location optimization, development of information technology and standards among different businesses, it may strengthen the presence of railway in the freight transport. In addition, intermodal freight transport can also be important in the disasters, since it can minimize the loss of freight transport and relief goods supplies by connecting available transport modes at hand.

Thus, merits of intermodal freight transport can be summarized as the improved flexibility, reliability and availability of freight transport. Other benefits of intermodal freight transport include less CO_2 emission and other environmental impacts, less cost especially in the long distance transport, less necessary personnel required compared to truck-dependent transport. In particular, recovery from natural disasters needs intermodal freight transport to sustain transporting urgently-needed relief supplies.

Table 1. Advantages and disadvantages of three major modes

Truck	Railway	Sea
+ Flexibility	+ Large capacity	+ Large capacity
- Limited capacity	+ Fast and accurate	- Less speed
- Lack of fuel	+ Lower environmental impact	- Connecting modes required for inland transport
	- Need of collections and deliveries by trucks	

6. Conclusions

Efficient and smooth intermodal freight transport has been realized more swiftly after Tohoku Earthquake as compared to Great Hanshin Earthquake and Niigata Chuetsu Earthquake. Lessons and know-how from past natural disasters are turned to advantages in this tragic event. It is clear that promoting intermodal freight transport may strengthen the presence of railway freight transport in the normal period. Moreover, flexibility and redundancy of intermodal freight transport will provide more robust function in transporting living necessities to the devastated areas after such large-scale natural disasters, where immediate supplies of reliefs are vital.

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